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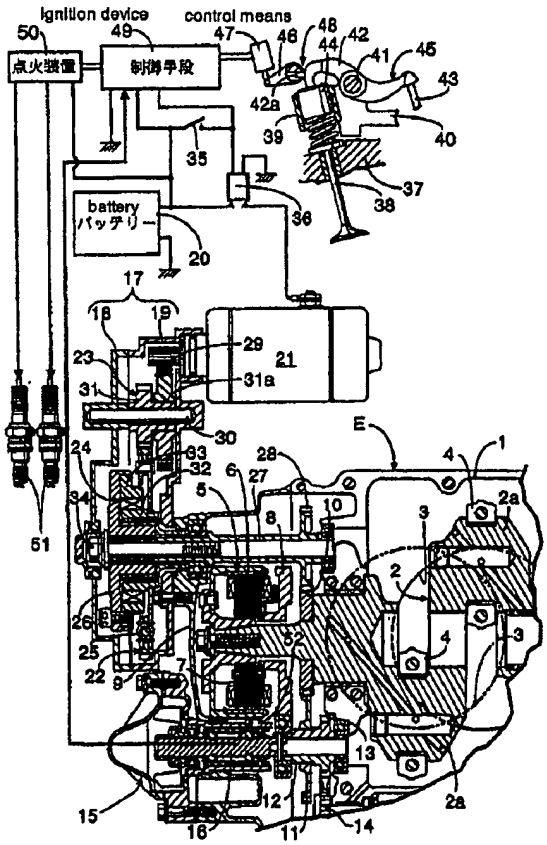
(54) Title: ENGINE STARTING APPARATUS



(57) Abrégé/Abstract:
To attain downsizing and weight reduction of starter motor and starting power transmission means, in an engine starting apparatus where the starting power transmission means, for decelerating rotation power of the starter motor and transmitting the power to a crankshaft, is provided between the starter motor that starts rotation by electric power supplied from a battery and the

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(57) Abrégé(suite)/Abstract(continued):
crankshaft, even in a multicylinder engine. An exhaust valve 38 is depressed and opened by actuation of an actuator 47 in accordance with actuation of a starter motor 21, and the actuation of the actuator 47 is continued until the number of revolutions of a crankshaft 2 detected by a revolution detector 52 reaches a predetermined number of revolutions.

ABSTRACT OF THE DISCLOSURE

To attain downsizing and weight reduction of starter motor and starting power transmission means, in an engine starting apparatus where the starting power transmission means, for decelerating rotation power of the starter motor and transmitting the power to a crankshaft, is provided between the starter motor that starts rotation by electric power supplied from a battery and the crankshaft, even in a multicylinder engine. An exhaust valve 38 is depressed and opened by actuation of an actuator 47 in accordance with actuation of a starter motor 21, and the actuation of the actuator 47 is continued until the number of revolutions of a crankshaft 2 detected by a revolution detector 52 reaches a predetermined number of revolutions.

JJ-11 495CA

TITLE: Engine Starting Apparatus

FIELD OF THE INVENTION

The present invention relates to an engine starting apparatus, and more particularly, to an engine starting apparatus in which starting power transmission means, for decelerating rotation power of a starter motor and transmitting the power to a crankshaft, is provided between the starter motor which starts rotation by electric power supplied from a battery and the crankshaft.

BACKGROUND OF THE INVENTION

Conventionally, such apparatus is already well known by e.g. Japanese Patent No. 3070086. In this apparatus, in a monocylinder engine, the starter motor and starting power transmission means are downsized without setting excessively high strength by providing a torque limiter mechanism to protect the starter motor against reverse operation of crankshaft upon engine startup in the starting power transmission means. Further, as disclosed in e.g. Japanese Published Unexamined Patent Application No. Hei 4-148008, the starter motor and starting power transmission means are downsized without setting excessively high strength by protecting the starter motor against reverse operation of crankshaft by opening an exhaust valve by decompression means in an initial compression stroke upon startup of monocylinder engine.

However, in a monocylinder engine, the starter motor and starting power transmission means can be downsized by providing a torque limiter mechanism or decompression means, as in the case of the above-described conventional art, but it is difficult to apply the above conventional art to a multicylinder engine

without any change. That is, in a multicylinder engine, since ignition is made at early timing in spite of great amount of inertia of the crankshaft, the crankshaft cannot be started without difficulty unless a limiter weight is set to a large value. Further, the decompression means cannot be actuated within a range of small crank angle without difficulty, the downsizing and weight reduction of the starter motor and starting power transmission means in the multicylinder engine cannot be attained without difficulty.

The present invention has been made in view of the above situation, and has its object to provide an engine starting apparatus which attains downsizing and weight reduction of starter motor and starting power transmission means even in a multicylinder engine.

SUMMARY OF THE INVENTION

To attain the foregoing object, the invention is characterized in that an engine starting apparatus wherein starting power transmission means, for decelerating rotation power of a starter motor and transmitting the power to a crankshaft, is provided between the starter motor that starts rotation by electric power supplied from a battery and the crankshaft, comprises: decompression means for depressing an exhaust valve thereby opening the valve, in correspondence with actuation of an actuator; a revolution detector that detects the number of revolutions of the crankshaft; and control means for controlling the actuation of the actuator by starting the actuation of said actuator in accordance with the actuation of said starter motor and continuing the actuation of said actuator until the number of revolutions detected by revolution detector reaches a predetermined number of revolutions.

According to this construction, the power from the starter motor is transmitted via the starting power transmission means to the crankshaft in correspondence with the actuation of the starter motor. As the actuator of the decompression means starts in accordance with the actuation of the starter motor and the exhaust valve is depressed thereby opened, the pressure in a combustion chamber in an engine compression stroke is reduced, and the engine starting torque can be greatly reduced. Further, the state where the open status of the exhaust valve depressed by the decompression means ends when the number of revolutions of the crankshaft has reached the predetermined number of revolutions. As the crankshaft has sufficient inertia even when the combustion chamber pressure in engine compression stroke increases to a normal state, the engine can be reliably started. In this manner, as the starting torque necessary upon engine startup can be reduced, and further, the decompression means is continuously actuated until the number of revolutions of the crankshaft reaches the predetermined number of revolutions regardless of ignition timing, the downsizing and weight reduction of the starter motor and starting power transmission means can be attained even in a multicylinder engine.

Further, in an aspect of the invention is characterized in that, in addition to the construction of the invention described said starting power transmission means is provided with a one-way clutch having a clutch member as one constituent that rotates at a speed higher than that of the crankshaft and that is always coupled to the crankshaft. According to this construction, the comparatively large inertia produced by the clutch member as one constituent of the one-way clutch is effectively utilized as inertia of the crankshaft, thus startup of the engine can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

[Fig. 1] A cross-sectional view of a part of the structure of the engine.

[Fig. 2] A side view of the engine mounted on the aircraft.

[Fig. 3] A cross-sectional view along the line 3-3 in Fig. 2.

[Fig. 4] An enlarged cross-sectional view along the line 4-4 in Fig. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Will be described in accordance with an embodiment of the present invention illustrated in the attached drawing.

In Fig. 1, this engine E is a V multicylinder engine mounted on a motorcar, a motorcycle, an aircraft and the like. Large ends of connecting rods 4, 4... are respectively coupled to plural crank pins 2a, 2a... of a crankshaft 2 rotatably supported in a crankcase 1. Small ends of the respective connecting rods 4, 4... are coupled to pistons (not shown) respectively slidably engaged in plural cylinder bores 3, 3... partially overlapped with each other in a plane projection including an axial line of the crankshaft 2.

One end of the crankshaft 2 is projected from the crankcase 1, and a rotor 6 of a generator 5 is coaxially coupled to the one end of the crankshaft 2. A stator 7 of the generator 5 is fixedly supported by a support plate 8 fixed to the crankcase 1. Further, a cover 9 covering the generator 5 is fastened to the crankcase 1.

A first gear 10 is fixed to the crankshaft 2 between the crankcase 1 and the support plate 8. A rotary shaft 12, to which second gear 11 engaged with the first gear 10 is fixed, is rotatably supported by the crankcase 1 and the support plate 8. Further, a third gear 13 is integrally provided with the rotary shaft 12, and the third gear 13 is engaged with a fourth gear 14 connected to a valve device 45.

A water pump 15 is attached to the cover 9, a pump shaft 16 of the water pump 15 is connected, coaxially and relative-unrotatably, to the rotary shaft 12, and rotation power from the crankshaft 2 is also transmitted to the water pump 15.

A gear case 17 made by connecting a pair of case members 18 and 19 is connected to the cover 9, and a starter motor 21 that starts rotation by electric power supplied from a battery 20 is provided outside the crankcase 1. The starter motor has a rotation axial line parallel to the crankshaft 2 and is supported by the gear case 17. Starting power transmission means 22 is provided between the starter motor 21 and the crankshaft 2.

The starting power transmission means 22 has a deceleration gear array 23 accommodated in the gear case 17 so as to decelerate and transmit the output from the starter motor 21, a one-way clutch 24 accommodated in the gear case 17, a damper spring 25 provided between the deceleration gear array 23 and the one-way clutch 24, a flywheel 26 fastened to a clutch outer member 33 as a clutch member constructing a part of the one-way clutch 24, a rotary shaft 27 coaxially connected to the flywheel 26, and a fifth gear 28 integrally formed with the rotary shaft 27 such that the fifth gear engages with the first gear 10 of the crankshaft 2.

A cylindrical shaft 31a of a gear 31, rotatably supported by a support shaft 30 with both ends supported in the gear case 17, is press-inserted in a gear 29 constructing a part of the deceleration gear array 23. The shaft 31a can be slided to the gear 29 upon input of excessive torque by surface processing on the shaft 31a. That is, the shaft 31a and the gear 29 construct a torque limiter mechanism.

The one-way clutch 24 has a clutch inner member 32 coupled to the deceleration gear array 23 via the damper spring 25 and the clutch outer member 33. The one-way clutch transmits rotation power in one direction, inputted into the clutch inner member 32 from the deceleration gear array 23 side, to the clutch outer member 33 side. When a revolution speed of the clutch outer member 33 connected to the crankshaft 2 in the one direction exceeds the revolution speed of the clutch inner member 32 in correspondence with startup of the engine E, the clutch blocks power transmission between the clutch inner member 32 and the clutch outer member 33.

The rotary shaft 27, with its one end projected into the gear case 17, is rotatably supported by the crankcase 1 and the cover 9. The flywheel 26 is spline-coupled to the one end of the rotary shaft 27 in the gear case 17, and a bolt 34 engaged with an outer surface of the flywheel 26 is engaged with the rotary shaft 27.

The fifth gear 28, integrally formed with the other end of the rotary shaft 27 and engaged with the first gear 10 of the crankshaft 2 has a diameter smaller than that of the first gear 10. The flywheel 26 and the clutch outer member 33 which rotate with the rotary shaft 27 are always coupled to the crankshaft 2, and they rotate at a speed higher than that of the crankshaft 2.

A relay 36 is provided between the starter motor 21 and the battery 20. Power supply and supply stoppage from the battery 20 to the starter motor 21, i.e., actuation and stoppage of actuation of the starter motor 21 is controlled by connection/disconnection of the relay 36 in correspondence with connection/disconnection of a starter switch 35.

Exhaust valves 38.are opnenably/closably provided in respective cylinders of a cylinder head 37 of the engine E. The exhaust valve 38 is opened/closed by the valve device 45, which has a holder 40, with a lifter housing 39 coaxial with an opening/closing actuation axial line of the exhaust valve 38, fixed to the cylinder head 37, a rocker arm 42 swingably supported by a rocker shaft 41 fixedly supported by the holder 40, a push rod 43 which applies an upward pressing force to one end of the rocker arm 42, a lifter 44 between the other end of the rocker arm 42 and the exhaust valve 38, slidably engaged in the lifter housing 39, and the like.

A decompression cam 46 is engaged with an engaging arm 42a provided on the other end side of the rocker arm 42 in the valve device 45. The decompression cam 46, and a solenoid 47 as an actuator coupled to the decompression cam 46 which is rotatable, construct decompression means 48.

The decompression means 48 depresses and opens the exhaust valve 38 by rotation of the decompression cam 46 by actuation of the solenoid 47. The actuation of the solenoid 47 is controlled by the control means 49.

The starter switch 35 is connected to the control means 49 for detection of actuation period of the starter motor 21. Further, a detection value from the revolution detector 52 to detect the number of revolutions of the crankshaft 2, attached to the cover 9 in a position opposite to the outer peripheral surface of

the rotor 6 in the generator 5, is inputted into the control means 49.

The control means 49 starts the actuation of the solenoid 47 in accordance with the actuation of the starter motor 21 to depress the exhaust valve 38 thereby open the valve, and continues the actuation of the solenoid 47 until the number of revolutions detected by the revolution detector 52 reaches a predetermined number of revolutions as a sufficiently high value, thus controls the actuation of the solenoid 47.

Further, the control means 49 also controls actuation of an ignition device 50 to ignite ignition plugs 51, 51 of the engine E. It is desirable that the control means 49 controls the ignition device 50 to start ignition of the ignition plugs 51, 51. in correspondence with stoppage of actuation of the solenoid 47 i.e. stoppage of actuation of the decompression means 48. Further, it is desirable that similar to the ignition start timing of the ignition plugs 51, 51, fuel injection start timing by a fuel injection valve (not shown) is determined as timing after the stoppage of actuation of the decompression means 48.

Next, the operation of the embodiment will be described. When the actuation of the starter motor 21 is started by bringing the starter switch 35 into conduction so as to start the engine E, the power from the starter motor 21 is transmitted via the starting power transmission means 22 to the crankshaft 2. In correspondence with the actuation of the starter motor 21, the control means 49 actuates the solenoid 47 of the decompression means 48, and the exhaust valve 38 is depressed and thereby opened by the decompression cam 46.

Accordingly, the pressure in a combustion chamber in a compression stroke of the engine E is

reduced, and the starting torque of the engine E can be greatly reduced. Further, as the open state of the exhaust value 38 depressed by the decompression means 48 ends when the number of revolutions of the crankshaft 2 has reached a predetermined number of revolutions and the crankshaft 2 has sufficient inertia even when the pressure in the combustion chamber in compression stroke of the engine E increases to a normal state, the engine E can be reliably started, and the starting torque necessary upon startup of the engine E can be reduced.

As the decompression means 48 continues actuation until the number of revolutions of the crankshaft 2 reaches the predetermined number of revolutions regardless of ignition timing, downsizing and weight reduction of the starter motor 21 and the starting power transmission means 22 can be attained even in a multicylinder engine E as in the case of this embodiment.

Further, the starting power transmission means 22 is provided with the one-way clutch 24 having the clutch outer member 33 which rotates at a speed higher than that of the crankshaft 2 and which is always coupled to the crankshaft 2, as one constituent. The comparatively large inertia produced by the clutch outer member 33 can be effectively utilized as the inertia of the crankshaft 2, thereby the startup of the engine E can be improved. Especially, as in the case of this embodiment where the flywheel 26 is fastened to the clutch outer member 33, the greater inertia produced by the clutch outer member 33 and the flywheel 26 is effectively utilized as inertia of the crankshaft 2, thereby the startup of the engine E can be further improved.

Further, if it is arranged such that the ignition of the ignition plugs 51, 51... is started and fuel injection is started, in correspondence with the

stoppage of actuation of the decompression means 48, the startup of the engine E can be further improved.

As described above, the embodiment of the present invention has been described, however, the present invention is not limited to the above embodiment, but various design changes may be made without departing from the present invention described in the scope of the claims.

For example, the multicylinder engine E has been described in the above embodiment, however, it goes without saying that the present invention is applicable to a monocylinder engine.

As described above, according to the invention, the starting torque of the engine is greatly reduced by reducing the pressure in the combustion chamber in compression stroke of the engine until the number of revolutions of the crankshaft reaches a predetermined number of revolutions. Thus the engine can be reliably started, and the downsizing and weight reduction of the starter motor and starting power transmission means can be attained even in a multicylinder engine.

Further, according to a preferred embodiment of the invention, the comparatively large inertia produced by the clutch member as one constituent of one-way clutch is effectively utilized as inertia of the crankshaft, thus the startup of the engine E can be improved.

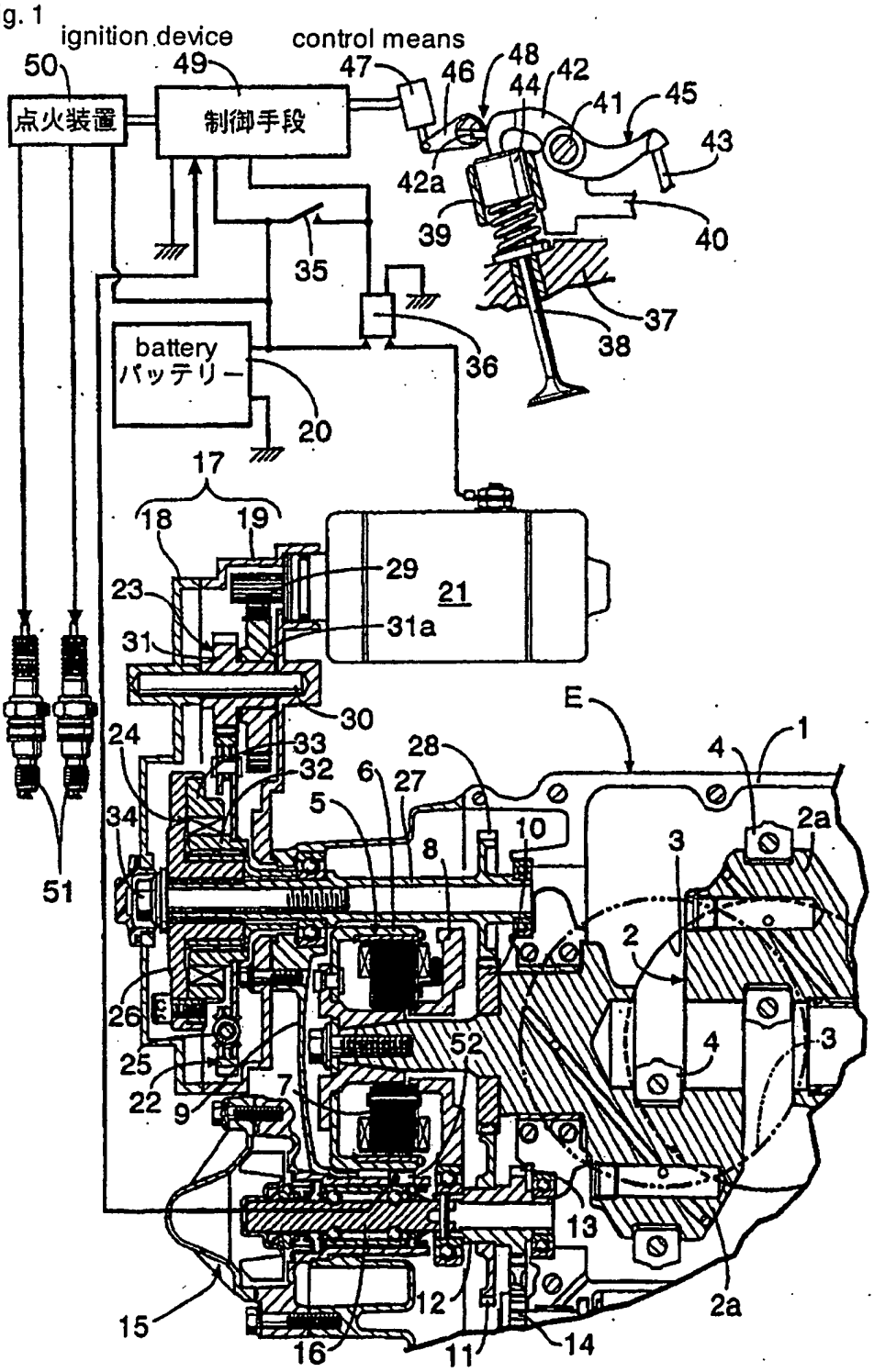
Although various preferred embodiments of the present invention have been described herein in detail, it will be appreciated by those skilled in the art, that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An engine starting apparatus wherein starting power transmission means (22), for decelerating rotation power of a starter motor (21) and transmitting the power to a crankshaft (2), being provided between the starter motor (21) that starts rotation by electric power supplied from a battery (20) and the crankshaft (2), comprising: decompression means (48) for depressing an exhaust valve (38) thereby opening the valve, in correspondence with actuation of an actuator (47); a revolution detector (52) that detects the number of revolutions of the crankshaft (2); and control means (49) for controlling the actuation of said actuator (47) by starting the actuation of said actuator (47) in accordance with the actuation of said starter motor (21) and continuing the actuation of said actuator (47) until the number of revolutions detected by said revolution detector (52) reaches a predetermined number of revolutions.

2. The engine starting apparatus according to claim 1, wherein said starting power transmission means (22) is provided with a one-way clutch (24) having a clutch member (33) as one constituent that rotates at a speed higher than that of the crankshaft (2) and that is always coupled to the crankshaft (2).

Fig. 1


ignition device
control means
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49
47
46
48
44
42
41
45
43
点火装置
制御手段
42a
39
40
35
37
38
36
battery
バッテリー
20
17
18
19
29
21
23
31
31a
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Fig. 2

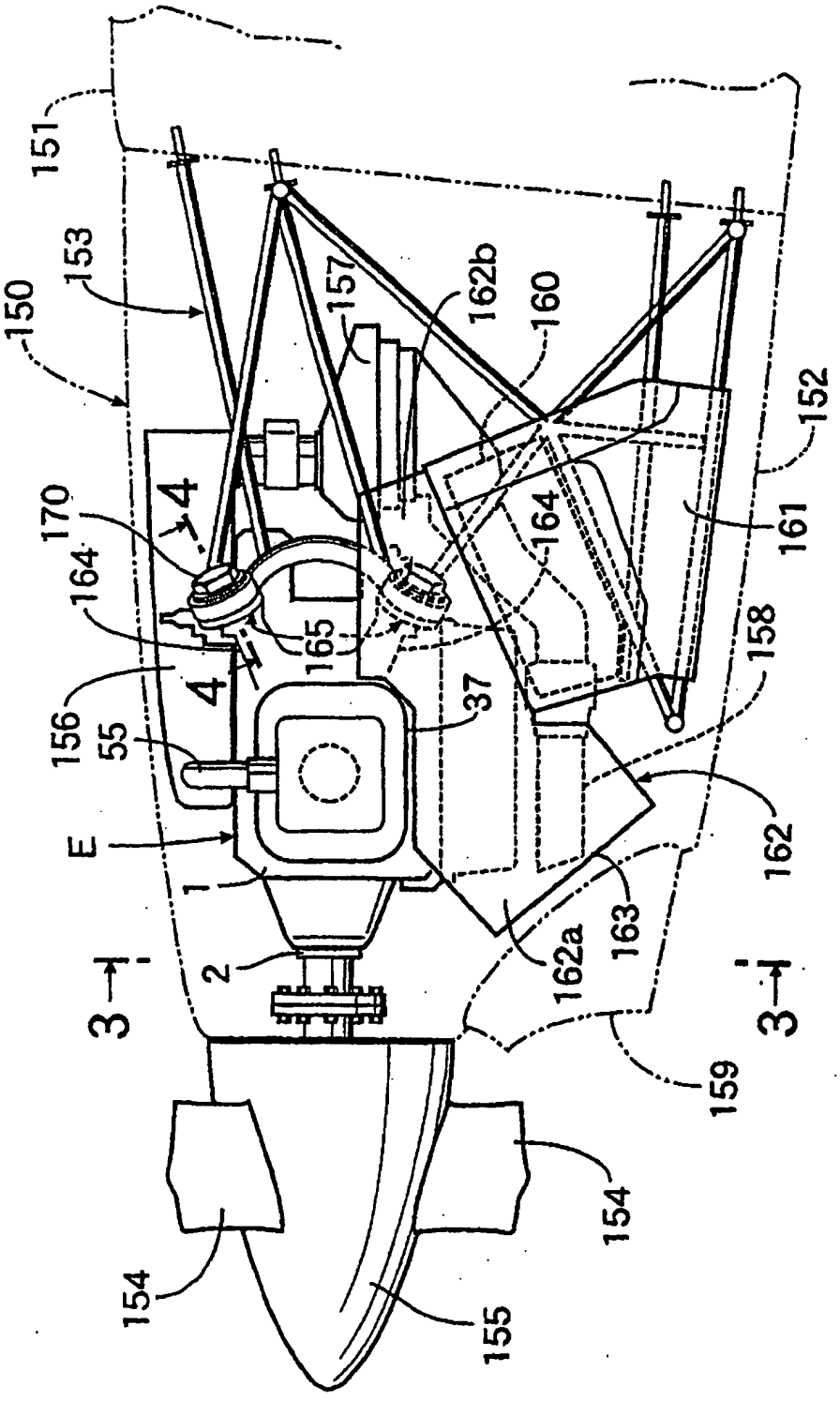
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Fig. 3

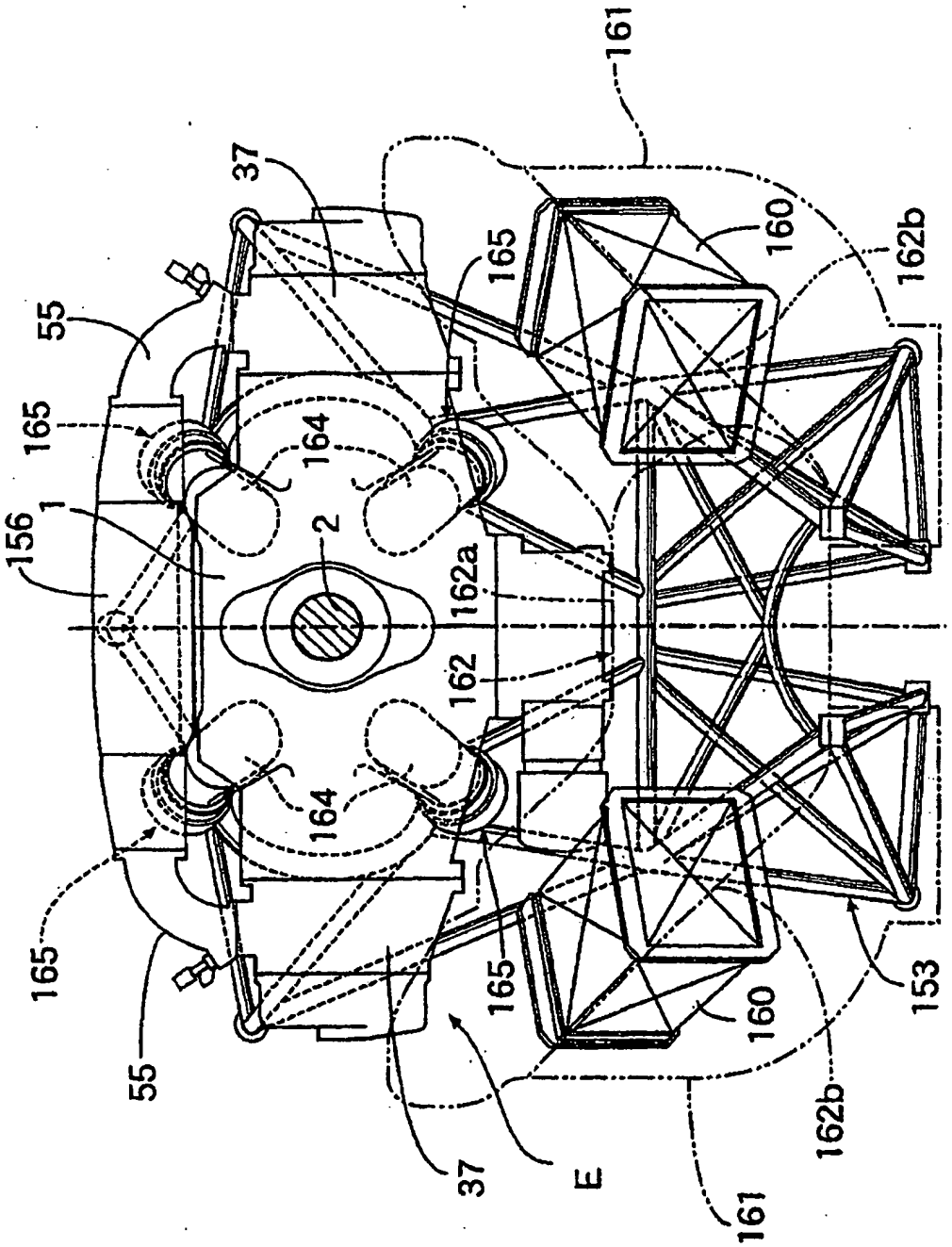
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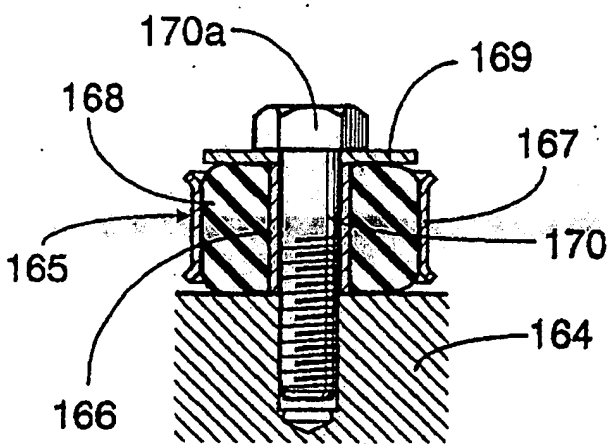
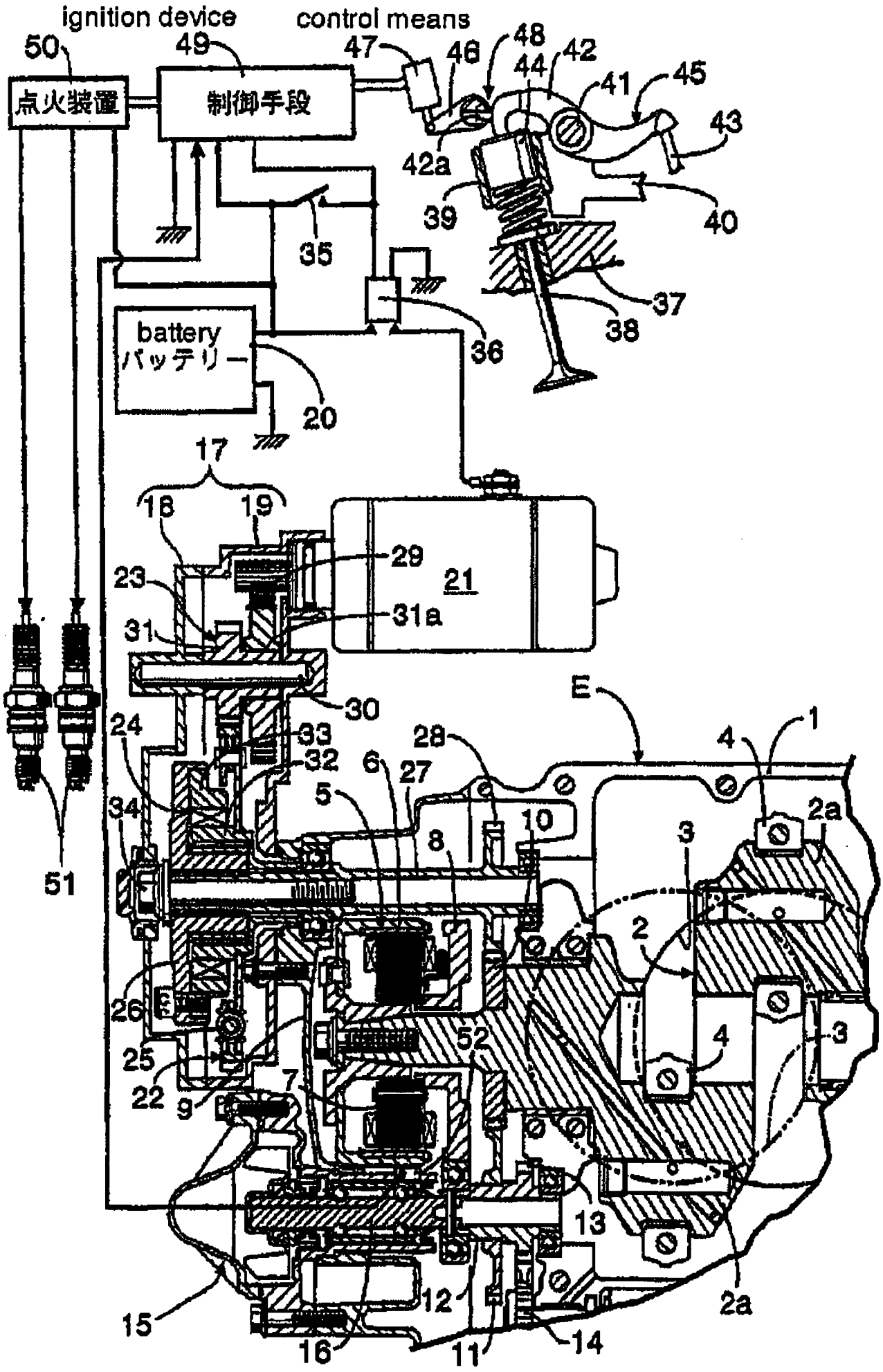
Fig. 4




ignition device
control means
点火装置
制御手段
battery
バッテリー
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